Global Air Quality Trekkers: Clean Kitchen Study

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Project Partners: ampath Leading With Care

Global Air Quality Trekkers

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Problem Statement

Many countries across the globe have large, rural areas where people must rely on **biofuels** for cooking. A typical biofuel stove, made of mud, is shown to the right.
This stove does nothing to direct the smoke emissions from the combustion chamber away from the user. This leads to women and children experiencing much higher rates of acute and chronic illnesses due to poor indoor air quality.

Map showing global mortality rates due to poor indoor air quality (Kenya circled in green)

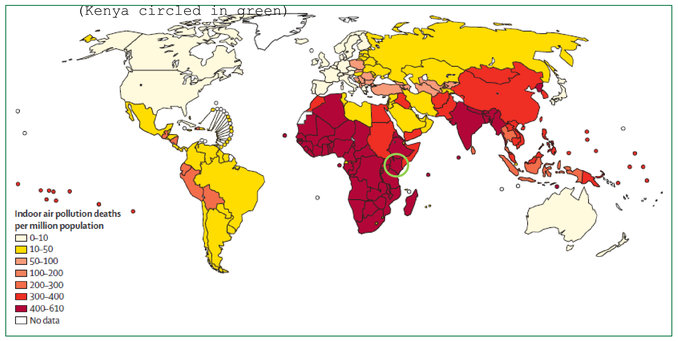


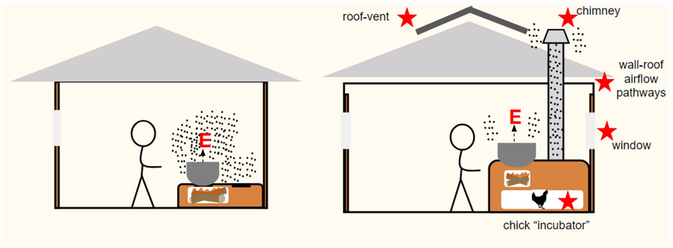
Figure 2: WHO map of household air pollution and mortality

The Mission of GAQT

To design and conduct experiments on our previously built test kitchen in order to analyze the effectiveness of different natural ventilation methods.

Project Background

- Though this is a global problem, GAQT is focused specifically on the **Nandi** community of **Kenya**
- The women of Nandi made several modifications to their traditional Nandi kitchens, as shown below



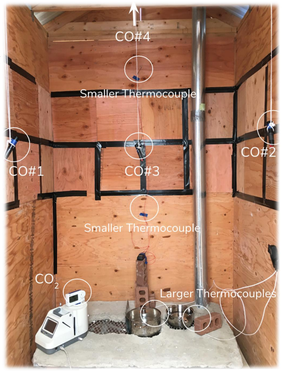
Traditional Nandi Kitchen Modified Nandi Kitchen

- In 2018, GAQT constructed a modular test kitchen in West Lafayette
- The test kitchen was designed to replicate a Nandi kitchen to allow the team to test different natural ventilation methods proposed by the women of Nandi

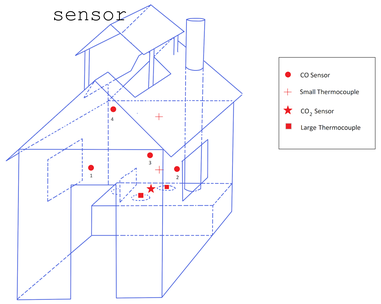
Materials and Methods

- 4-Carbon Monoxide Sensors
- 2-Thermocouples
- 1-Carbon Dioxide Sensor
- 1-Particulate matter sensor
- 1-Differential Pressure sensor

Sensors

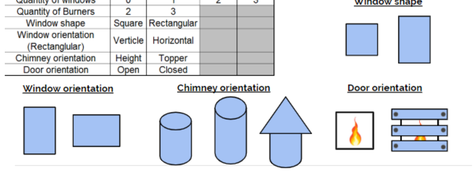


Sensors placed within test kitchen for experimentation



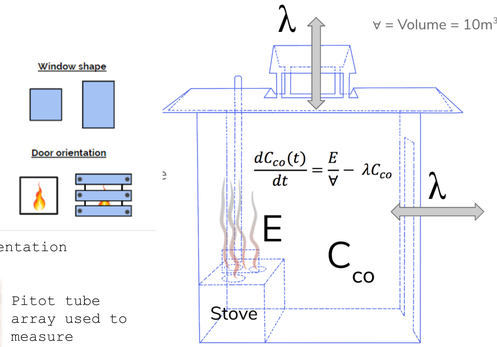
Sensor layout in test kitchen

Experimental Variables	Variances			
Quantity of windows	0	1	2	3
Quantity of Burners	2	3		
Window shape	Square	Rectangular		
Window orientation (Rectanglular)	Verticle	Horizontal		
Chimney orientation	Height	Topper		
Door orientation	Open	Closed		



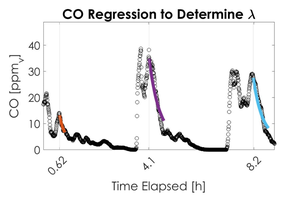
Statement of variables for experimentation

Pitot tube array used to measure pressure difference at window (left)

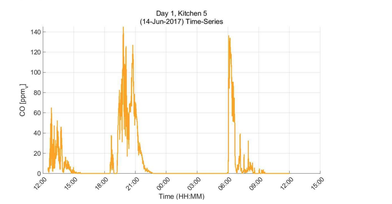


Mass balance mathematical model of test kitchen to find the emission rate (E)

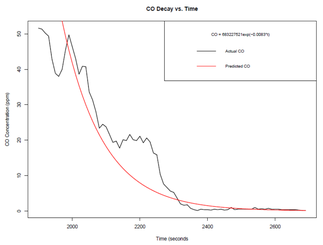
Results



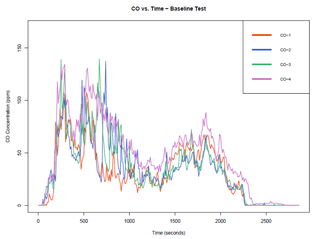
CO decay curve for Nandi kitchen



CO concentration over 24 hours in Nandi kitchen



CO decay curve for test kitchen, used to determine ventilation rate



CO concentration over one test in test kitchen

$$E = C_{co} \forall \lambda$$

$$E = \left(85\frac{mg}{m^3}\right)(10m^3)\left(19\frac{1}{h}\right)\left(\frac{1hr}{60min}\right) = 270\frac{mgCO}{min}$$

Equations to calculate emission rate of test kitchen stove

Conclusions

GAQT's test kitchen in West Lafayette

Kitchen in Nandi, Kenya

Based on preliminary CO concentration and decay data, GAQT has found that the test kitchen built can produce data comparable to data collected in Nandi kitchens. This means that data collected in the test kitchen can be applied to Nandi kitchens, given reasonable correction factors for wind and other weather conditions.

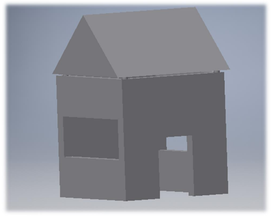
Ongoing and Future Work

- GAQT will continue to run experiments and collect data throughout the Spring 2019 semester in order to analyze the effectiveness of multiple natural ventilation methods
- Study abroad to Nandi in May 2019

May 2019:
GAQT travels to Nandi, Kenya!

Study Abroad Goals:

- Strengthen relationship with Nandi community and project partners
- Collect data in Nandi kitchens
- Share data from experiments with community
- Present an educational module at the Tumaini Innovation Center



GAQT at Tumaini Innovation Center:

- Engage in cross cultural development with students
- Develop and run two educational modules focused on indoor air quality and related to GAQT's mission
  - Practicing creative problem solving with kitchen mini models
  - Building environmental sensors in Arduino